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SOME FUNGUS PARASITES OF ALGAE[1]

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(WITH EIGHT FIGURES)

About twelve years ago I was giving considerable attention to the study of the parasites of the algae in the vicinity of Ithaca, N. Y. At that time I hoped that the investigations might eventuate in a monograph of the Chytridiales of the Cayuga Lake basin. The pressure of other investigations has almost completely interrupted these studies. Because of our limited knowledge of the occurrence and habits of these interesting fungi in North America, it has seemed to me desirable that the observations already made should be recorded, in the hope that this may stimulate a greater interest in these plants.

As a result of the studies three papers have already been published. An extended paper on the genus Harpochytrium in the United States was published in 1903,[2] a summary of which later appeared in the *Journal of mycology* in 1904.[3] A short note on the interesting behavior of the zoospores of *Rhizophidium globosum* while escaping from the zoosporangium was published in 1894.[4] This behavior related to the habit of their sensing or feeling the exit opening in the sporangium, which they do by means of pseudopod-like extensions of the protoplasm in different directions, after having come to rest on the inside of the zoosporangial wall. In case they happen to come to rest close by the exit they "feel" it by one of the pseudopods, and slide out.

[1] Contribution from the Department of Botany, Cornell University, No. 133.

[2] ATKINSON, G. F., The genus Harpochytrium in the United States. Ann. Myc. 1:479–502. *pl. 10.* 1903.

[3] ———, Note on the genus Harpochytrium. Jour. Myc. 10:3–8. *pl. 72.* 1904.

[4] ———, Intelligence manifested by the swarm-spores of *Rhizophidium globosum.* BOT. GAZETTE 19:503, 504. 1894.

In case they are distant from the exit, not finding it they round up into the motile zoospore form again and swarm around in the zoosporangium for a time, and coming to rest make another trial. It is evident that when the zoosporangium is filled with the zoospores the latter will escape quite rapidly for a time because so many of them are crowded successively against the exit. As the numbers diminish there is greater freedom for swarming. The zoospores then swarm around and around in great circles inside the wall of the zoosporangium, now and then coming to rest and feeling around for the exit. This same behavior has been observed in the case of a number of other species. In addition to this a quite remarkable phenomenon was observed in the case of another species, *Rhizophidium brevipes*, which will be described below.

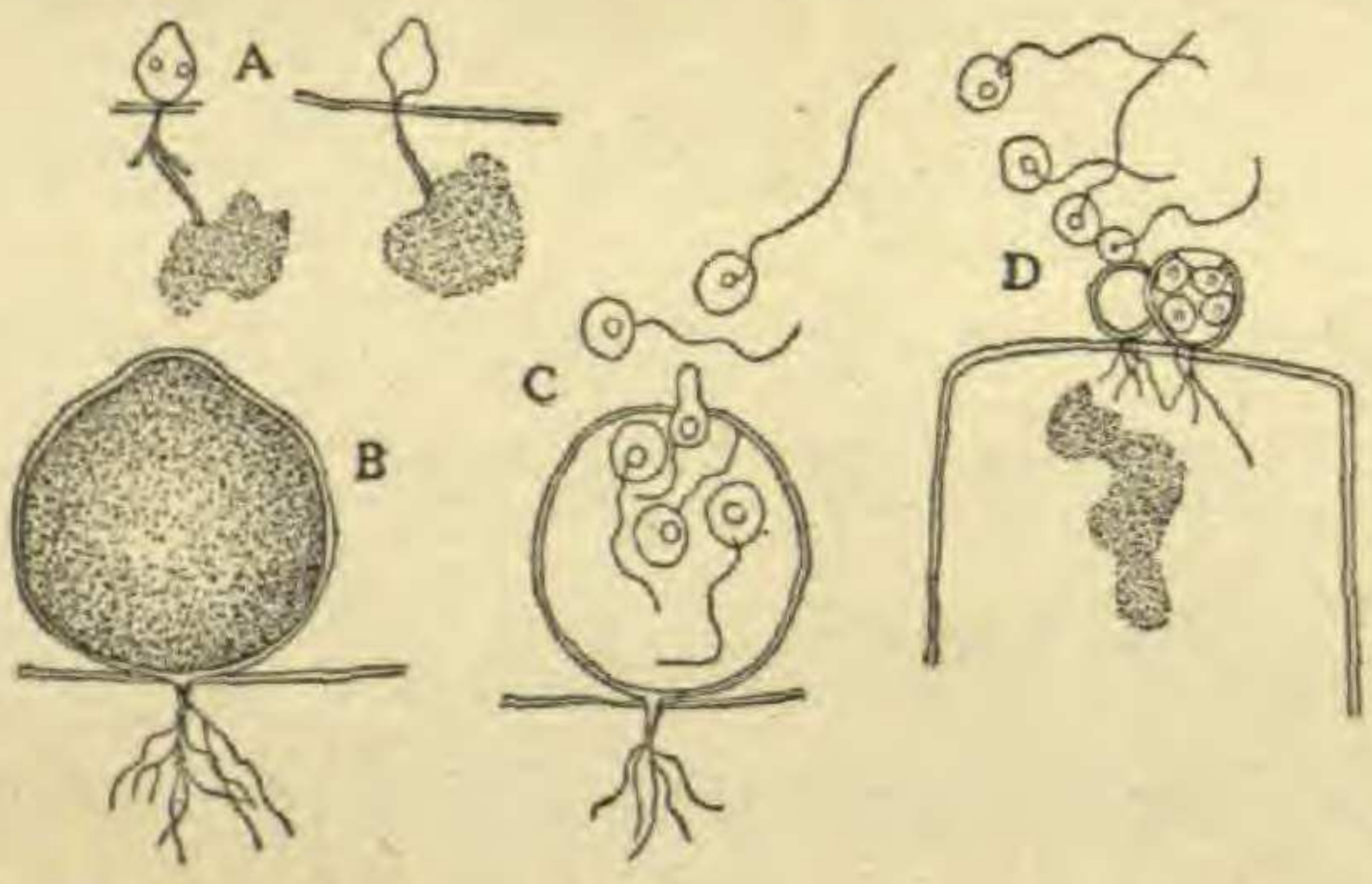

FIG. 1.—*Rhizophidium globosum* (A.Br.) Schröt. *A* young plant, shortly after germination of zoospores with germ tubes, penetration tube forming rhizoids; *B* mature plant ready to form zoospores; *C* zoospores escaping; *D* much smaller plants.

In the presentation of these observations I shall make no attempt to arrange the genera in any natural order of relationship, this matter being reserved for a future work. Since a number of species of Rhizophidium were studied I will begin with this genus.

RHIZOPHIDIUM BREVIPES

This was collected in a pool beyond Forest Home, N. Y., a little more than one mile from Ithaca. It was attached to the wall of a fruiting cell of *Spirogyra varians*. The zoosporangium is oval with a small apical papilla. The wall shows two distinct layers, an outer rather thick one and an inner thin one. At the time of the maturity of the zoospores the papilla of the outer layer becomes gelatinized at the apex, forming a minute opening about 4 μ in diameter.

One very characteristic feature of this species is the very rudimentary condition of the rhizoids. The very slender branched rhizoids so characteristic of *R. globosum* and other species appear to be absent. The penetration tube of the zoospore forms a short stalk, which projects but a short distance within the cavity of the host cell. This rudimentary condition of the rhizoids recalls that of *Harpochytrium hedenii* Wille, though in the latter it penetrates only the outer lamella of the wall and flattens out in the form of a disk in the middle lamella, or merely penetrates a thin layer of slime on the host and flattens out on the outer wall (ATKINSON 1903). This penetration tube serves also as the absorbent organ for such food as the plant obtains from the fluids within the gametangium of the host surrounding its zygospore. The zoosporangium measures 21–24 μ, while the zoospores are about 3 μ in diameter, with a single cilium and a prominent oil drop.

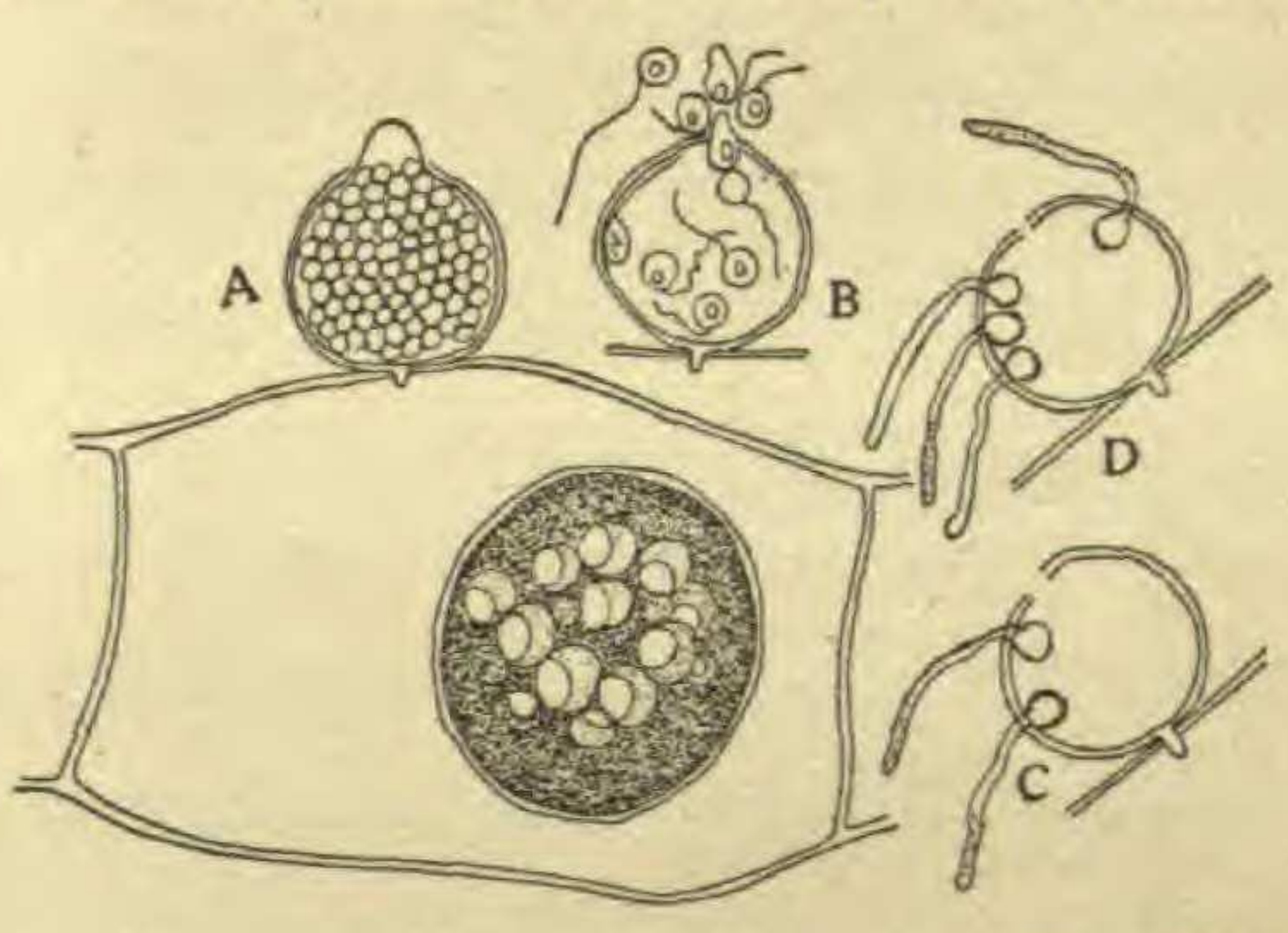

FIG. 2.—*Rhizophidium brevipes* Atk. *A* mature zoosporangium crowded with zoospores, outer layer of wall at exit pore dissolving, inner layer projecting as a papilla before the rupture, plants attached to a gametangium of Spirogyra containing zygospores; *B* zoospore escaping; *C* two zoospores, unable to escape by exit pore, have germinated and are attempting to escape through germ tube, protoplasm in the apex of the tube; *D* same later, showing how the zoospores retreated from the first tubes and after swarming around for the second time attempted to escape again by the germ tubes.

The species was first observed in a cell preparation which was made on April 24, 1895, at about 4 P. M. The zoosporangium was mature and the protoplasm finely granular. In the course of half an hour from the time of the first observation, the granules began to arrange themselves in numerous small groups, the beginning of the formation of the zoospores. Very soon these began to disappear and were gradually replaced by a prominent oil drop for each group of granules. Each oil drop was surrounded by a hyaline mass of homogeneous protoplasm. The preparation was watched for the greater part of the time from 4 P. M. until 6 P. M., and fresh water was frequently drawn in, in order to hasten the development and maturity of the zoospores. At this time it appeared that the zoospores would not become mature under an hour, and the preparation was placed in a moist chamber until 7 P. M. It was then examined and fresh water added. The apical portion of the outer wall was dissolved;

soon the inner wall at this point became ruptured, and precisely at 7 P. M. the zoospores began their escape. The number of zoospores was very large and they were packed so tightly in the zoosporangium that it was impossible for them to make other than slight amoeboid movements. Those at the apex slowly moved through the opening one or two at a time, so that the number could be readily counted. In passing through the opening the zoospore puts forth a stout hyaline projection which feels and leads the way, and then the body slowly moves through. On the outside, at the mouth of the zoosporangium, each zoospore rests for a short time, during which a few plastic movements are exhibited; then it rounds off and darts away.

When 50 or 60 zoospores had made their escape in this way the space in the zoosporangium was not so crowded, and a few of those at the center began active swarming movements, while those at the periphery of the sporangium were quiet or only exhibited plastic movements, and those nearest the opening continued to escape in the manner described. This continued until there were very few still within the zoosporangium. The remainder of the zoospores were all swarming, and at times some of them would come to rest on the side of the wall, put out by amoeboid movement a short pseudopodium, and feel evidently for the opening. Not finding it they would swarm around within the zoosporangium again, and again come to rest, maneuver for the opening, and on finding it escape. This manner of finding the opening is the same as that described for *R. globosum* (ATKINSON 1894), but as the opening is larger than in that species, the body of the zoospore does not become constricted at the passage. At 7:18 P. M. all but four of the zoospores had made their escape, and in four minutes more two of these had escaped, leaving two still within the zoosporangium. These were watched for an hour longer, and they divided the time in swarming and feeling for the exit, but were unable to escape; though several times they located themselves directly at the opening, they seemed to be insensible of it.

The preparation was placed in the moist chamber and left for the night. On the following morning both of the zoospores were found located on one side of the zoosporangium and each had germinated.

The slender germ tube, having penetrated the wall of the zoosporangium, extended in a tortuous course for a distance of 15–20 μ. The preparation was examined several times during the day. Since one of the zoospores was located not far from the wall of the spirogyra, it was hoped that the thread would find the cell and enter it, inasmuch as it was pointed in that direction. The preparation was left in this condition during another night, the slender tube of the zoospore nearest the spirogyra cell not yet having reached it. On the following morning the preparation was examined again, and I was surprised to find that one of the zoospores was on the other side of the zoosporangium. Close examination showed that both had moved during the night. Not being able to find any suitable nourishment, the protoplasm in each germinating cell had migrated back from the inclosing membrane into the zoosporangium, formed a zoospore, and had passed through a second swarming period. Then coming to rest again they had germinated, the germ tube of each having again penetrated the wall of the sporangium and formed a slender tube 15–20 μ long. The preparation was kept for a day longer, but the zoospores did not form again.

This behavior of the zoospores is quite interesting, since it manifests not only a sort of "ingenuity" in the attempt to escape from the zoosporangium, but, what is more important, the tendency, under certain conditions of existence which prevent the zoospore from seeking a host cell by the normal planetic method, to migrate in the form of a true mycelial tube, which is quite different from the very delicate slender absorbent rhizoids normally developed from the germ tube in other species of the genus.

Rhizophidium brevipes, n. sp.—Zoosporangia oval, 21–24 μ in diameter, with a papilla at the apex, in which the exit pore is formed. Rhizoidal apparatus very rudimentary, consisting of the short, blunt, unbranched entrance tube of the zoospore, which projects but a very short distance beyond the inner lamella of the wall of the host. Zoospores oval with an oil drop, uniciliate, 3 μ in diameter.

On walls of gametangia of *Spirogyra varians* in which zygospores are formed. Vicinity of Ithaca, N. Y.

Zoosporangiis ovatis, apici uno, brevi, papilliformi ostiolo, basi, uno brevi, non ramoso tubulo. Zoosporis ovoidiis, 3 μ latis, una guttula hyalina et uno cilio praeditis.

RHIZOPHIDIUM SPHAEROCARPUM

Rhizidium sphaerocarpum Zopf, Nova Acta Leop.-Carol. Deutsch. Akad. **47**:202. *pl. 19. figs. 16–27.* 1884.

Rhizophidium sphaerocarpum A. Fischer, Rabenh. Krypt. Flora Deutschl. Oesterr. u. Schweiz 2 Aufl. **4**:95. 1892.

What I have taken to be this species occurred in abundance on threads of *Mougeotia parvula* collected in a gutter on Thompson St., Ithaca, N. Y., April 7, 1895. The zoosporangia are oval in form and vary considerably in size, the larger ones measuring 16–18 × 18–20 μ, while the smaller ones are about 10 × 11 μ. They occur singly or in groups of two to four, the smaller ones more commonly in groups and the larger ones rarely so. The rhizoids are very much reduced, consisting of a few very short branches from the short entrance tube.

The wall of the zoosporangium consists of two lamellae, an outer stout lamella and a thin inner membrane. This is very well seen in the dehiscence of the zoosporangia. At maturity the apex of the outer wall of the zoosporangium dissolves, forming a large circular opening for the exit of the zoospores. Through this the inner membrane projects in the form of a short broad papilla by the swelling of the epiplasm. The final rupture of this membrane sets the zoospores free, and the large opening permits their rapid escape. The exit pore measures 5–6 μ in diameter in the larger forms, and in the smaller ones is proportionately larger, being 4–6 μ in diameter, some of the smaller zoosporangia appearing like cups when open. The zoospores are oval, possess a long cilium and a prominent oil globule, and measure 1.5–2 μ in diameter. In germination, if the germ tube is directed toward the wall of the host cell, it penetrates the wall, and then the zoospore enlarges to the size of the mature plant, becoming the zoosporangium. If, however, as sometimes happens, the germ tube is directed away from the wall, or along its surface, it may grow to a considerable distance, sometimes reaching a length of 30 μ. The zoosporangia sometimes grow so as to appear attached by their side instead of by their base, and the opening is then at the side (*fig. 3, C*).

In nearly all of the larger specimens (which may prove to be a different species) the effect on the host cell was quite remarkable. The host cell not only becomes considerably larger near the middle, but is very much elongated. Frequently at the middle it is not much larger, while on each side an enlargement occurs (*fig. 3, D, G*). The stimulus which causes the increase in the length and size of the cell also increases the development of the chromatophore. When this influence ceases the chromatophore begins to degenerate, the color

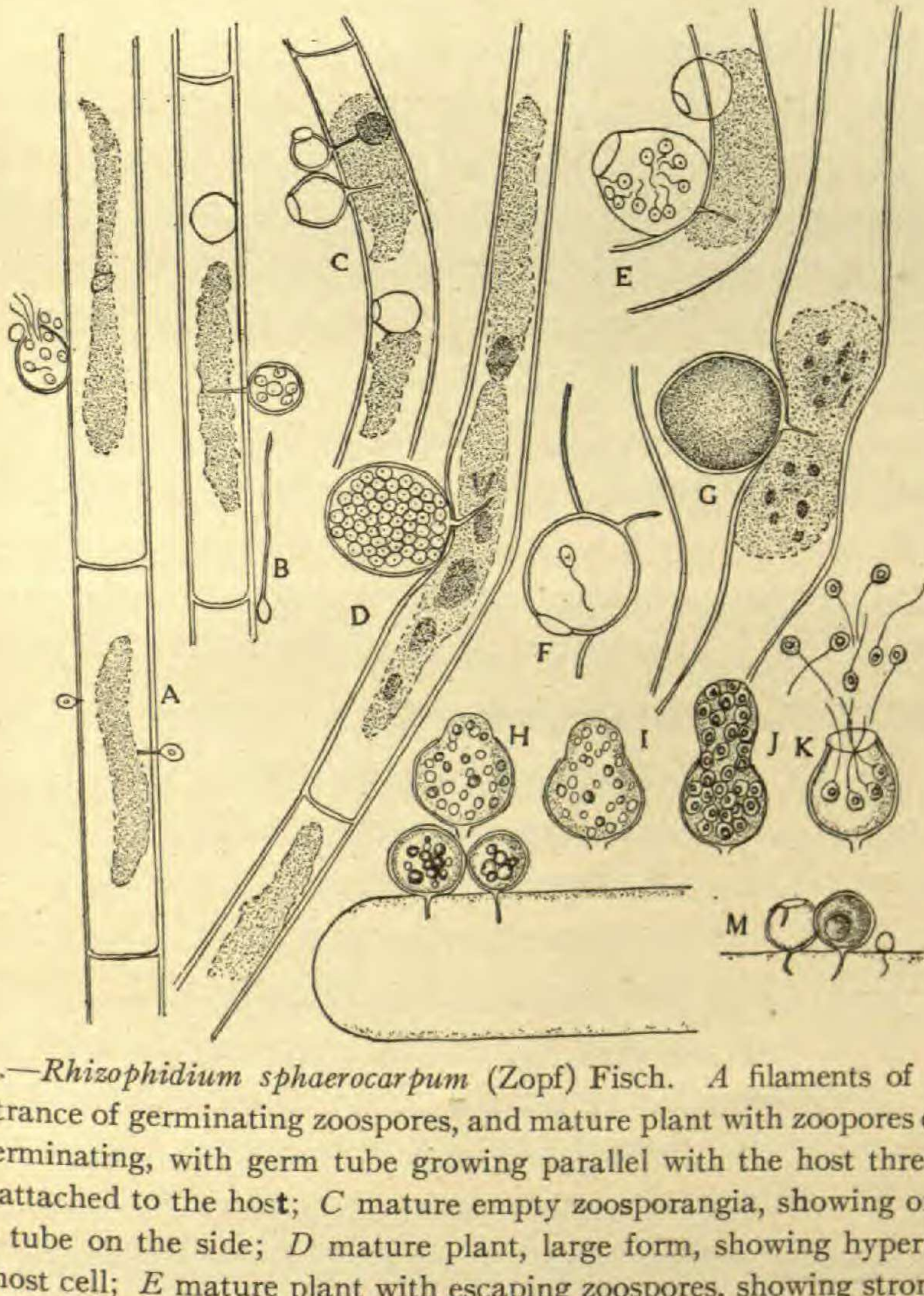

FIG. 3.—*Rhizophidium sphaerocarpum* (Zopf) Fisch. *A* filaments of Mougeotia showing entrance of germinating zoospores, and mature plant with zoopores escaping; *B* zoospore germinating, with germ tube growing parallel with the host thread, mature plants also attached to the host; *C* mature empty zoosporangia, showing one with the penetration tube on the side; *D* mature plant, large form, showing hypertrophy and curving of host cell; *E* mature plant with escaping zoospores, showing strongly curved host cell; *F, G* showing hypertrophy of host cell; *H–M* different stages in the opening of the zoosporangium and escape of the zoospores; *A–G* original; *H–M* after ZOPF.

fades, the structure breaks down, and the processes of dissolution separate it into small particles with the pyrenoids more distinct, all coalescing into an amorphous mass, which gradually flows toward the middle of the cell where the sporangium is located. This may be due partly to the fact that the cell of the host is larger at that point, as well as to an influence which the parasite exerts upon it, for it is possible that the crowding of the chromatophores from each side toward the middle may cause the two enlargements near the middle with the constriction between them (*fig. 3, G*). Not only does the influence of the parasite excite these changes in the host cell, but it also causes the cell to become more or less strongly arched at the point of insertion of the sporangium, the sporangium being in the concavity of the arched thread. This effect has only been noted in connection with the larger forms, except where the smaller ones are several in a group, and here the curving of the thread is slight in comparison with that which exists in the case of the larger sporangia. ZOPF (*l. c.*) does not mention any similar hypertrophy of the host cell caused by this species, nor is it shown in his illustrations. He figures the plant on Spirogyra. A. FISCHER (*l. c.*) reports it on various filamentous Conjugatae and Oedogoniaceae, but does not mention any hypertrophy of the host.

Germinating zoospores have been observed in this species in which the germ tube may become directed away from the host and develop a mycelial tube 15–20 μ in length.

RHIZOPHIDIUM MINUTUM

This species was collected on *Spirogyra varians* in a pool beyond Forest Home, N. Y. (about one mile from Ithaca), April 23, 1895. It frequently accompanies Lagenidium, but also occurs independently of it. The zoosporangia are sessile, very small, obpyriform or flask-shaped. Thus the species belongs to the *longata* section of the genus. The zoosporangia are 5–6 μ in diameter. At the base are a few slender rhizoidal threads which extend a short distance in the host cell content. The form of the zoosporangium thus presents a broad and prominent apical papilla, the end of which becomes gelatinized at maturity of the zoospores, forming a circular exit pore. The zoospores are few in number, two to four in the cases observed. They measure 2.5 μ in diameter, and are provided with one cilium and a prominent oil drop.

FIG. 4.—*Rhizophidium minutum* Atk. Elongated zoosporangium, rhizoids, and zoospores.

Rhizophidium minutum, n. sp.—Zoosporangia obpyriform or flask-shaped, broadly papillate, 5–6 μ in diameter, sessile with a few slender rhizoidal filaments at the base in the host cell. Apex opening by a single pore. Zoospores two to four in a zoosporangium, oval, uniciliate, with a single oil drop, 2.5 μ in diameter.

On *Spirogyra varians* in the vicinity of Ithaca, N. Y.

Zoosporangiis obpyriformibus, 5–6 μ latis, apice una lata papilla, basi filamentis brevibus radiciformibus. Zoosporis ovoidis, 2.5 μ, una guttula hyalina et cilio simplici attenuato praeditis.

Lagenidium rabenhorstii[5]

This species was first found in a species of Spirogyra in a stream of slow-running water in the valley south of the city of Ithaca. It has since been found in various species and appears to be quite common. The fungus attacks the vegetative cells and those just about to conjugate. The zoospore enters the cell wall by a small perforation, the slender entrance tube growing usually nearly to the center of the host cell, where it enlarges to the size of the vegetative thread of the parasite. The general course of the threads is parallel with the axis of the spirogyra cell, though frequently tortuous and curved, with here and there short branches. The threads are usually stout, varying in diameter from 3 to 8 μ. At the ends of the cell of the host they curve around and frequently extend back to the other end, one to three and four threads thus lying in a single cell. The protoplasm possesses numerous highly refringent granules and there are also vacuoles at short distances. In other cases the thread may be strongly curved, or even coiled at various points within the end of the cell.

The chromatophores of the spirogyra are broken down and usually adhere to the threads of the fungus here and there, giving portions of them a green appearance in the early stages, and later a greenish brown as the chlorophyll becomes more and more disorganized. All traces of the chlorophyll at length disappear, and the fungus, lying in a disorganized mass of transparent protoplasm, is then seen distinctly throughout its entire length. In other cases the fungus thread may be permanently soiled by the brownish matter of the disorganized chlorophyll.

The exit tubes are developed from the ends of the threads, or from the ends of the short lateral branches, or from the side of the main

[5] Zopf, W., Ueber einen neuen parasitischen Phycomyceten aus der Abtheilung der Oosporeen. Bot. Verein Prov. Brandenburg **20**:77–80. 1878. See also, Zur Kenntniss der Phycomyceten (Zur Morphologie und Biologie der Ancylisteen und Chytridiaceen). Nova Acta Kais. Leop.-Carol. Deutsch. Akad. Naturf. **47**:143–236. *pls. 12–21.* 1884.

thread itself, in the latter cases usually arising from the outer convexity of a curved portion of the thread. The exit tube is about 2 μ in diameter and projects but a little way outside of the wall of the host. The tube develops quite rapidly. In observations on cell cultures where I have been watching for the migration of the protoplasm through the exit tube, forming ones have been observed to develop in two to four hours time. The end of the tube becomes gelatinized and the protoplasm moves in a quite rapid stream through the tube, the small spherical mass of protoplasm at the mouth of the tube growing rapidly in size until all the protoplasm has passed through, which takes only a few seconds. In a few moments rotary motion begins, slow at first. Soon the constriction of the mass occurs in lines over the surface, in such a way as to divide the surface into 2–8 portions according to the size of the mass and the number of the zoospores to be formed. In this species I have not observed any inclosing membrane, nor any evidence that such a membrane exists, though ZOPF (*l. c.*, p. 149, 1884) describes and figures one. The constriction goes on from the surface toward the center, and soon the cilia are developed, their slow waving aiding in the slow but perceptible oscillatory motion of the mass. Plastic movements of the mass and the developing individuals also accompany the other movements. When division has become nearly complete, small portions frequently become constricted from the ends of the ovate to reniform individuals, the constriction becoming deeper and deeper, until in many cases the small portion becomes separate from the larger mass (*fig.* 5, *C*). These can be seen to be separate from the larger ones by the gliding motion of the zoospores over each other, and over the smaller bodies. The movements become more and more active, occasionally one zoospore pulling strongly in

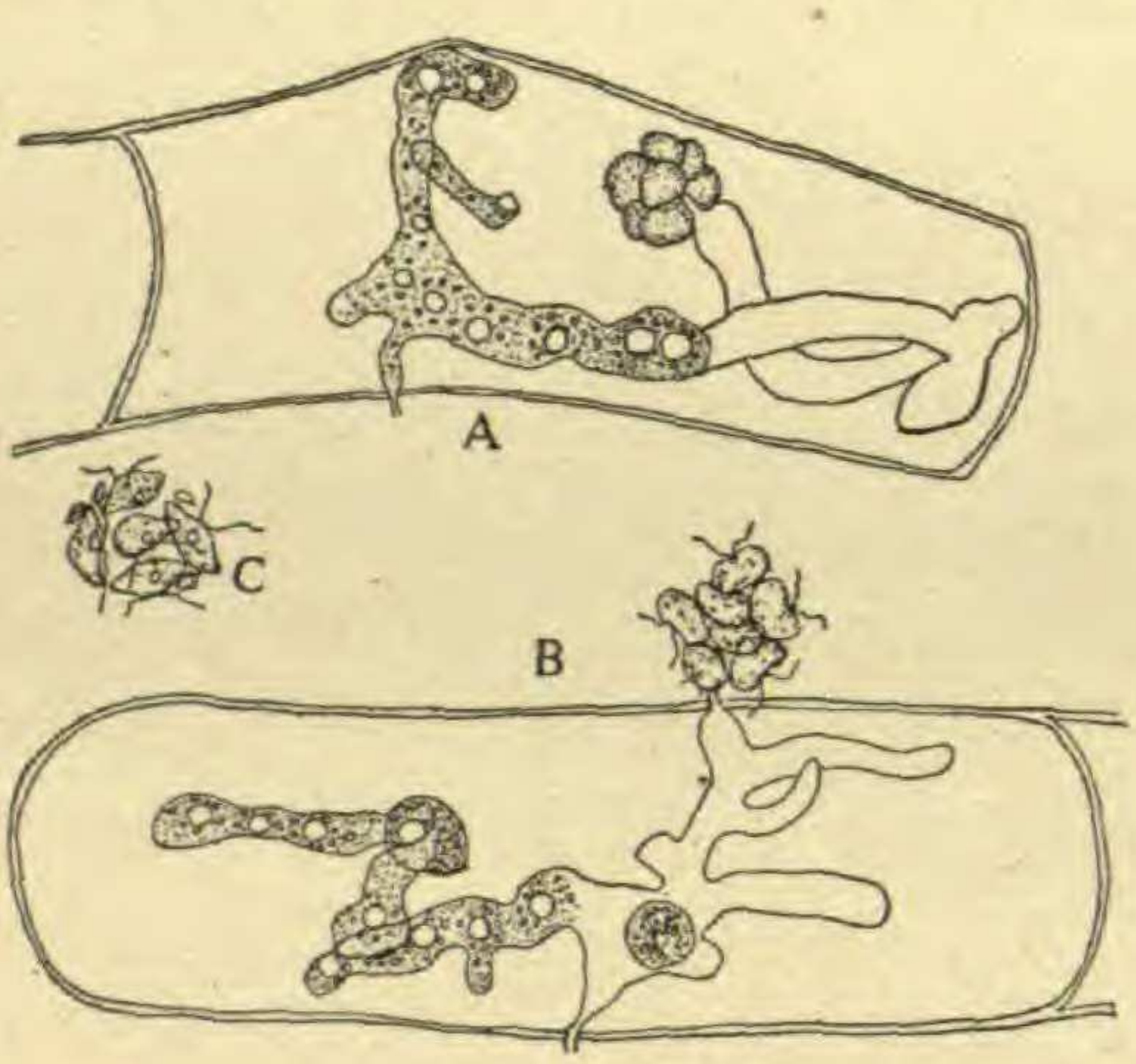

FIG. 5.—*Lagenidium rabenhorstii* Zopf. *A* thallus and prosporangia, which are sections of the thallus; *B* zoospores forming at the apex of the exit tube; *C* zoospores and small particles separated from them.

one direction and separating itself from the group by several millimeters; then it is drawn back again to its fellows as if by a retractile cord; then another will separate in the same manner, only soon to be drawn back again. This pulling away and returning becomes more and more accentuated each time, until finally one of the zoospores makes its permanent escape, leaving the others to struggle still for freedom. One by one, or two or more at a time, they escape in this manner and whirl away. This mode of escape would indicate that there is no inclosing membrane.

Before the escape of the zoospores, in cases where small portions of the zoospores have become separated, they may fuse or conjugate with the large ones again, but whether with the same one from which they were separated or with a different one could not be determined, since the gliding and rotary movement of the individuals and the mass would prevent absolutely the following of the separate ones through their various evolutions. DEBARY[6] (p. 37, 1881) first observed a separation of portions of the protoplasm and their fusion again with the parent masses in the formation of the oospores of the Saprolegniaceae, and it has since been observed in the oospores by HARTOG[7] (p. 24) and HUMPHREY[8] (p. 90). It was first observed in the zoospores of the Saprolegniaceae by Rothert[9] (1887, also p. 322, 1890; see also HARTOG, *l. c.*). When fusion did not take place before the zoospores made their escape from the group, the smaller portions would not then fuse with the larger ones, even if they came by accident in contact with them, so far as I was able to observe. In other cases the small portions of protoplasm might become partially separated from the larger ones, and the zoospores escape with a minute appendage attached either at one of the extremities or upon

[6] DEBARY, A., Untersuchungen über die Peronosporeen und Saprolegnieen und die Grundlagen eines natürlichen Systems der Pilze. Beitr. Morph. u. Phys. der Pilze **4**:1–145. *pls. 1–6.* 1881.

[7] HARTOG, M. M., Some problems of reproduction. Quart. Jour. Micr. Sci. **33**:1–79. 1892.

[8] HUMPHREY, J. E., The Saprolegniaceae of the United States, with notes on other species. Trans. Am. Phil. Soc. **17**:63–148. *pls. 14–20.* 1893.

[9] ROTHERT, W., Die Entwickelung der Sporangien bei den Saprolognieen. Beitr. Biol. Pfl. **5**:291–349. *pl. 10.* 1890. This paper first appeared in Polish in the Proceedings of the Cracow Academy **17**:———. 1887.

the more convex side, where it gave the zoospore the appearance of being a "hunch back." Such zoospores would perform very curious evolutions in their vain efforts to throw off the offending appendix, but in no case observed did this separation take place after the zoospores had separated from the group at the mouth of the exit tube. The number of zoospores from a single zoosporangium is 2–8, as stated above, or possibly a few more in some cases, the number depending upon the size of the sporangium.

In one case observed, where the zoospores seemed to be rather sluggish in their development and the movements not so active, the form was not so pronouncedly reniform, but more nearly oval, and after separating very little active movement took place, the individuals soon rounding off as they do when ready to germinate. Two such zoospores soon came in contact and immediately fused into a larger one, the fusion taking place in about ten seconds. The further fate of these zoospores was not followed. This fusion may be due to the peculiar conditions of environment, perhaps to the want of fresh water in the limits of the cell culture. From some observations made on the developing zoospores under similar conditions, it appears possible that it may be due to the variations of tension existing between the individuals and the original mass of protoplasm, the tension of the entire mass being directed toward keeping the mass intact and the tension of the individuals tending to separate the masses into smaller individuals. Two cases were observed which had progressed to some extent toward the formation of the zoospores. In one case there were two zoospores forming and in the other case four zoospores were forming from the spherical protoplasmic mass, which had collected at the end of the exit tube after passing from the sporangium. In each case the zoospores were about one-third formed. The preparation had been in the cell culture for two days and the water had been replenished a few times, as it had partially evaporated, by running fresh water under the cover from the edge, the cell cultures being made simply between the cover glass and the glass slip and not in a ring-cell, or VAN TIEGHEM cell. The oxygen thus accessible to the organism was very small, though this did not seem to hinder the development during study, if water were added every few moments, as would be necessary when the preparation was not protected in a moist chamber. While these two developing groups of zoospores were under observation, the water, which had not been changed for some time, slowly evaporated, so that a portion of it was removed from under the cover. At this time it was noted that the dividing protoplasmic mass, where there were two forming zoospores, was fusing again, and soon the mass was spherical, with no sign of the division which up to this time was quite marked, and showed all the phenomena of movement and formation of cilia which accompany the normal development of the zoospores, except that the movements were not so active. Very soon also the four forming zoospores in the other group were fusing and the movements had likewise ceased. The fusion in this case also continued until there was no trace of the forming zoospores, the mass was again spherical, and movement had ceased.

Thinking this might be due to the want of fresh water, some was quickly run under the cover glass, and the observation was renewed. The smaller protoplasmic mass burst on the absorption of the water, so great was the tension, but the larger one soon began slow rotary movement again and the constrictions appeared a second time, indicating the formation of four zoospores. This time the division proceeded, accompanied by all the phenomena of the formation of the zoospores noted in the normal cases, until the zoospores were complete and whirled away.

This would suggest that there were two opposing tensions in the formation of the zoospores, one individual and under normal conditions the stronger, and the other belonging to the mass and the weaker. When the conditions favorable for the formation of the zoospores ceased, the individual tension lessened to such a degree that it was lower than that of the mass, and the separating smaller portions were drawn together again in the common larger mass. These two opposing tensions might possibly explain the peculiar behavior of the zoospores when they still remain closely associated in the group, now partially separating and again coming close together, continuing this process of coquetting until the individual tension is strong enough to free them, in the case of those where there does not seem to be any inclosing membrane. The tension of the entire mass may possibly be somewhat similar to the force called adelphotaxy by HARTOG[10] (p. 216) in the case of the escaping zoospores of Achlya and Aphanomyces.

In some of the cell cultures in which numerous zoospores of Lagenidium were developing, there were several sun animalcules (*Actinophrys sol*). Some of these were so full of zoospores which they had caught, that they appeared to be a rounded collection of the zoospores, the convex outer portion of the zoospore only showing, and the entire surface of the Actinophrys appearing like a piece of mosaic made up of these unfortunate creatures. The delicate arms or rays of the Actinophrys radiated for a distance of 20–30 μ, and in a large number of cases which were observed, whenever a zoospore passed within reach of these rays, no matter how swiftly it was moving, it was suddenly paralyzed and halted; then the reniform shape gradually became spherical and it was slowly drawn by "invisible threads" to the body of the Actinophrys and slowly wedged its way between those which had preceded it.

LAGENIDIUM AMERICANUM

Another species of Lagenidium, which seems to differ from any described, was found in various species of Spirogyra (*S. varians, S. calospora*, and *S. insignis*) collected in a pool beyond Forest Home, April 11, 1895. It is parasitic in the zygospores and conjugating cells of the spirogyras, but has not been observed to develop in the vegetative cells. The vegetative phase of the fungus consists of strongly curved and coiled tubes, 4–8 μ in diameter, the size varying so that the contour and diameter of the threads is very irregular. It is profusely branched, and has also numerous short branches. It frequently fills the zygospores so completely that the individual course of the thread can be followed for only a short distance. At maturity the tube, as in the other species, is separated into segments of various lengths by the development of cross-walls, forming the zoosporangia. Frequently there is a constriction at the septum. Numerous zoosporangia are developed in a single zygospore. The exit tubes are slender, measuring about 2 μ in diameter, and of variable length according to the direction in which they emerge from the zygospore and the wall

[10] HARTOG, M. M., Recent researches on the Saprolegnieae. Annals of Botany 2:201–216. 1888.

of its parent cell. If the zoosporangium is located at the periphery of the zygospore near the middle, the tube is quite short. In the case of the zoosporangia which are located at the ends of the zygospores, the length of the exit tube is considerably longer, even when it is directed from the start perpendicularly to the wall of the parent spirogyra cell. In many cases, however, the exit tube from the zoosporangia which lie at the ends of the zygospore starts out nearly parallel with axis of the spirogyra cell, or at some angle between this and the perpendicular. In such cases the exit tube may be very long and tortuous, frequently passing into the adjacent spirogyra cell and finally emerging through the wall of the latter.

The protoplasm, with numerous small highly refringent granules and a number of vacuoles, presents practically the same appearance as in the case of the other species. It passes in a rapid stream through the exit tube and collects in an irregularly spherical mass at the extremity, from which in some cases it soon becomes free and floats to a short distance. In ten minutes from the passage slight rotary movements begin, the mass turning a short distance in one direction, and then in a moment in the other direction, the movement becoming faster and repeated at shorter intervals.

In some cases the cilia can be seen as delicate rays, even before the simultaneous constriction of the mass begins and they are slowly lashing. In other cases they are observed very soon after the constriction of the mass begins which outlines the surface of the individual zoospores. No inclosing membrane was observed, and it seems impossible that it should exist if the cilia can extend for such a distance from the mass. As the division proceeds the reniform shape of the individuals becomes more and more pronounced, and the movements become more and more violent. The individuals divide the time in a quivering motion followed by the oscillatory movements and the gliding over one another until they are apparently separate, now one pulling off a short distance, then returning, and so on, until they make their escape one after another or several at a time. After separating from the group, movement in space is rather slow, as if they were uncertain how to use the freedom gained. The individual oscillates and glides around in various curves, then becomes nearly stationary and quivers for a moment; then, one end remaining stationary, the other executes in succession several jerks or nods as if striking at something; then it enters upon another series of evolutions. After a short time thus engaged, the activity of the zoospore increases, the field covered by its evolutions becomes larger, and it is lost from the field of the microscope. In some cases which were timed the zoospores were separate in 25–30 minutes from the time the

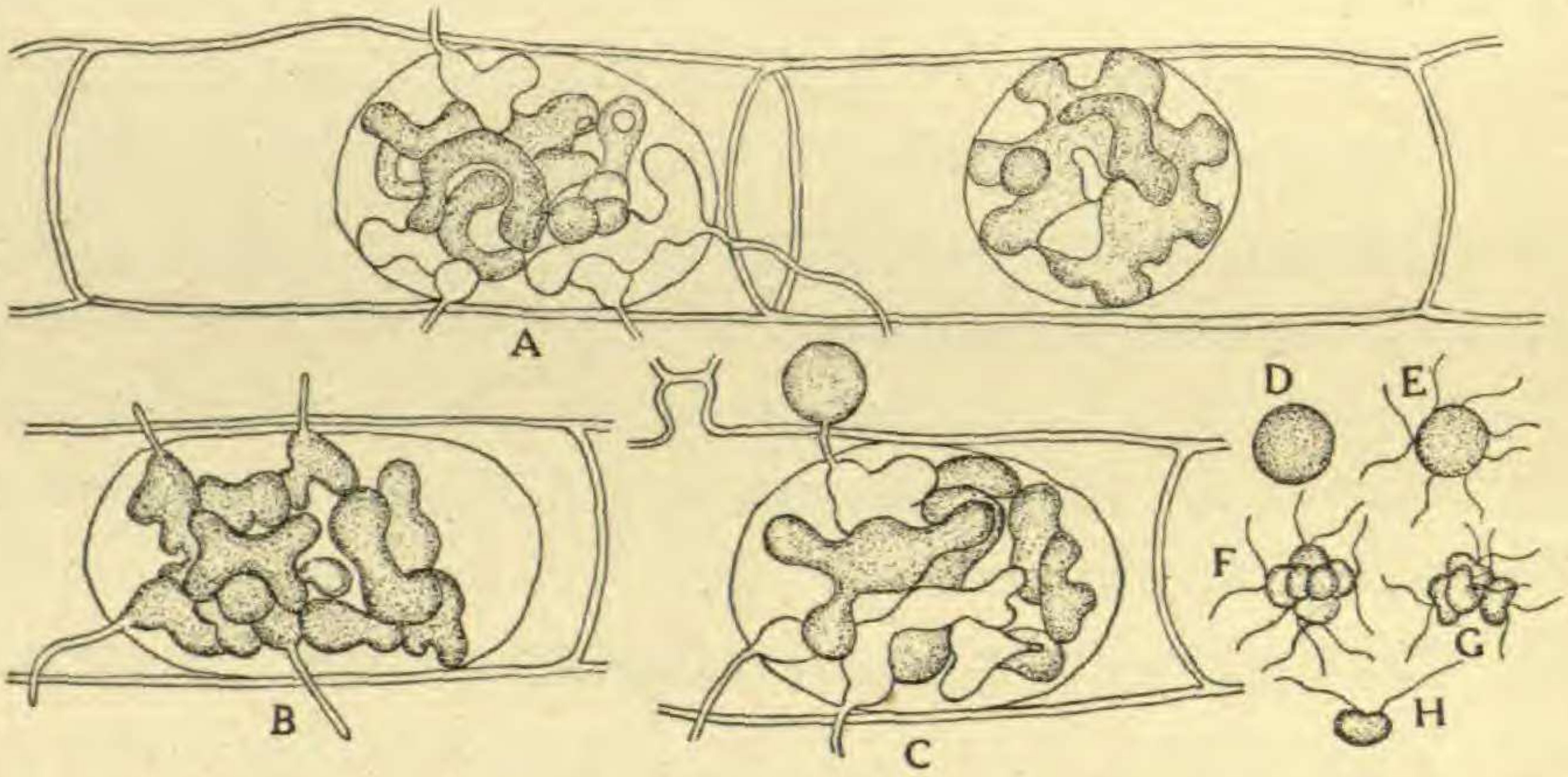

FIG. 6.—*Lagenidium americanum* Atk. in zygospores of Spirogyra. *A*, *B* some empty and some mature prosporangia; *C* from one prosporangium the protoplasm has just issued from the exit tube; *D* plasma sphere or zoosporangium proper free from the exit tube and floating in water; *E* formation of cilia where a zoosporangium is swimming around as a multiciliate spore; *F*, *G* different stages in formation and separation of zoospores, the groups swimming around like a pandorina colony; *H* mature and separate zoospore.

protoplasm passed from the exit tube. In those cases where the plasma vesicle at the end of the tube becomes free and floats away, the cilia develop on its surface, and it at first presents the appearance of a multiciliate spore. Later the divisions occur in such a way as to leave two cilia with each forming zoospore, and the colony then resembles a pandorina colony.

Lagenidium americanum, n. sp.—Plant body in the form of irregular tubes, much branched, curved, and of unequal diameter, confined within the host zygote, 3–8 μ in diameter. Exit tubes slender, short, 2 μ in diameter, varying in length but extending a short distance outside of the gametangium wall, of equal diameter from the point where they pierce the wall of the zygote to the outer free end, thus differing from the exit tubes of *L. entophytum* (Pringsh.) Zopf. Exit tubes arising from the end of hyphae or branches, or from the convex side of curved or enlarged portions. Zoosporangia of varying size, irregular and often branched, formed from segments of the thallus. Plasma sphere at the end of the exit tube often becoming free and floating away (the cilia then forming on the outside of the sphere), and finally dividing into the individual zoospores, the whole resembling a pandorina colony, but at last the zoospores separating. Zoospores reniform, laterally biciliate, 4–6×5–7 μ.

In zygospores of *Spirogyra varians, S. insignis*, and *S. calospora*, Ithaca, N. Y.

Mycelio inequali, curvato, ramulo irregulare instructo, 3–8 μ lato. Zoosporangiis irregularibus, saepe ramulosis. Ostiolo tubiformi tenuissimi aequali, 2 μ lato. Prosporangiis ramulosis sectionibus mycelii formatis. Zoosporangiis vesiculosis, saepe deciduis, ciliis ornatis, ut coenobio Pandorinae natantibus, postremo divisis, zoospores formantibus. Zoosporis fabaeformibus, laterale biciliatis, 4–6×5–7 μ. Hab. in zygosporis Spirogyrae, Ithaca, N. Y.

PHLYCTOCHYTRIUM PLANICORNE

This genus, *Phlyctochytrium* Schroeter,[11] differs from Rhizophidium in the presence of a swelling on the penetration tube, just inside the host cell wall, from which the delicate nutritive rhizoids grow. *Phlyctochytrium planicorne* has been found quite frequently in company with *Lagenidium americanum*, in the cells of *Spirogyra varians*, from the pool beyond Forest Home (near Ithaca). The zoosporangium is a little broader than long, measuring 6×8 μ, and is broadest in the middle. At the apex it is provided with four plain dentate processes around the exit pore. These dentate processes are characteristic of one section of the genus (*Dentigera* ROSEN,[12] SCHROETER, *op. c.*, p. 79). The endophytic bladder-like base of the plant is separated from the epiphytic zoosporangium by a constricted portion at the point where the penetration tube passes through the cell wall of the host. This base is about 3 μ in diameter, and from it radiate several slender branching threadlike rhizoids. No zoospores have as yet been observed. While it very frequent'y accompanies Lagenidium, it is by no means confined to the cells affected by the fungus, being found on other cells also.

FIG. 7.—*Phlyctochytrium planicorne* Atk.

Phlyctochytrium planicorne, n. sp.—Zoosporangium broadly elliptical, 6×8 μ, armed at the apex with four plain teeth. Endophytic vesicle globose, 3 μ in diameter, with several radiating branched slender rhizoids.

On cells of *Spirogyra varians*, often accompanying *Lagenidium americanum*, near Ithaca, N. Y.

[11] SCHROETER, J., in ENGLER & PRANTL, Pflanzenfam. 1[1]:78. 1892.

[12] ROSEN, F., Ein Beitrag zur Kenntniss der Chytridiaceen. Beitr. Biol. Pflanzen 4:253–266. *pls. 13, 14.* 1887.

Zoosporangio ellipsoideo, 6×8 μ, apice 4 cornuis ornato. Cellula inferiori 3 μ lata. Hab. in *Spirogyra varianti.*

PHLYCTOCHYTRIUM EQUALE

This species inhabits the cells of Spirogyra, having been found in the cells of *S. insignis*, collected in the pool beyond Forest Home, April 17, 1895. The epiphytic sporangium and the subsporangial endophytic base are about equal in size, being spherical in form and about 6 μ in diameter. The mouth of the sporangium appears to have two small teeth, which may be the walls of a short canal. From the base of the subsporangial part of the plant are several branching rhizoid-like threads. Zoospores have not been observed.

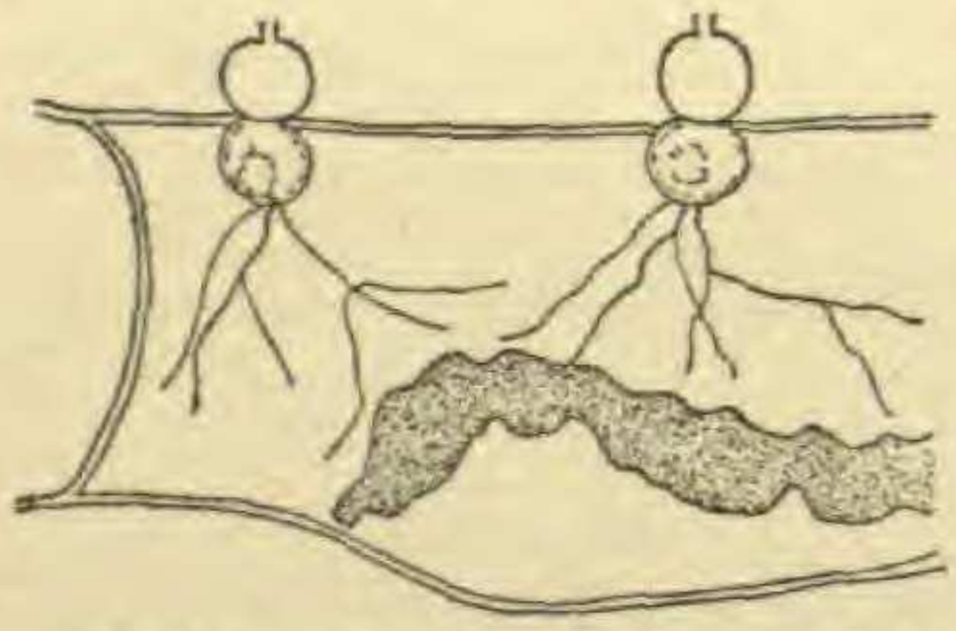

FIG. 8. — *Phlyctochytrium equale* Atk.

Phlyctochytrium equale, n. sp.—Zoosporangium globose, sessile, about 6 μ in diameter. Subsporangial base equal in size, with several long branched rhizoid filaments from its base.

Zoosporangio globoso, sessili, 6 μ lato, basi subsporangiali aequali, rhizoideis filamentibus ramulosis praedito. Hab. in *Spirogyra insigne.*

A few other species have been observed but not studied further than for their identification. They are as follows:

Lagenidium enecans Zopf (p. 154, 1884), in *Stauroneis phoenicentron* and *Cymbella lanceolatum*, in swamps near Freeville, N. Y., May 5, 1895.

Entophlyctis bulligera (Zopf) Fischer (*Rhizidium bulligerum* Zopf, p. 195, 1884), in *Spirogyra insignis* in pool at Forest Home, N. Y., April 17, 1895.

Rhizophidium ampullaceum (A. Br.) Schroeter, on sterile threads of Oedogonium, Freeville, N. Y., May 4, 1895.

Ectrogella bacillariacearum Zopf (p. 175, 1884), in diatoms, south end of Cayuga Lake, Ithaca, N. Y.

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